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<p>PUBLISHED SEMI-MONTHLY WITH ILLUSTRATIONS</p> <p>132 BROADWAY, NEW YORK &amp; 43 ST. MARTIN'S LANE, LONDON</p>	

From the author.

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## THE DIAGNOSIS OF TRAUMATIC SEPARATION OF THE EPIPHYSES.\*

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Consulting Surgeon to the St. Pancras and Northern Dispensary, etc., etc.

\*Being an unpublished paper read before the West Kent Medico-Chirurgical Society, April, 1886.





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**A**LTHOUGH the main features of the subject of this paper are well known to all, there are several points of great practical importance in connection with it, the proper consideration of which can alone lead to a correct diagnosis.

Detachments of the epiphyses or parts of the epiphyses are of daily occurrence, yet, compared with fractures in children, how small in number are the cases on record where an accurate diagnosis has been made and how few of our standard text books and works on surgery give us at all an adequate account of this most important, interesting, and difficult class of injury.

It is the diagnosis alone which can make us cautious, as much in the treatment of these cases as in the matter of prognosis. These injuries being so liable to be followed by deformity, suppuration, stiffness of a neighboring joint, and by imperfect or irregular development of the limb, we should at once warn the parents of the serious nature of the injury. A professional reputation might be easily destroyed did we not fully explain the nature of the case, the deformity and im-

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paired usefulness that may ensue in the limb in a few years, and point out all that may occur in spite of the most careful and skilful treatment of the case.

Simple separation of an epiphysis from the shaft, with more or less displacement, may be tolerably easy of recognition by the ordinary rules of surgery, but it is the complicated cases and cases of detachment of part only of the epiphysis, with fracture of the diaphysis, that may mislead and throw us off our guard. The latter may also be combined, though rarely with dislocation of the epiphysis.

To make the subject as clear as possible I shall remark upon the chief points in the diagnosis of epiphysal injuries collectively, at the same time describing several of the more common separations, giving examples.

Let us take six points, placed in the order of their importance, or more correctly their trustworthiness.

1. Age of the patient.
2. Mobility corresponding to an epiphysis.
3. Displacement at an epiphysal line.
4. Modified crepitus.
5. Character of displaced diaphysis or epiphysis.
6. Joint frequently intact.

1. *As to Age.*—These injuries can only occur, as a rule, in patients below 21 or 23 years of age, before the epiphyses have become united by bone to the shaft. A few instances have been recorded beyond this age, but I am inclined to put down these exceptional cases, like those occurring in young infants, as the result of some diseased or at any rate altered condition of the bone.

Contrary to the generally accepted views, I believe traumatic separation of the epiphyses, especially those of a simple character, to be comparatively rare in young children, and this I shall presently explain. When we come to closely examine into this question of age it will be found that the epiphyses of certain bones are liable to be broken off at particular periods.

I was greatly struck with this fact when examining the specimens of epiphysal separation in the museums of London and elsewhere. Taking for example the lower epiphyses of the femur, which according to museum specimens is more frequently affected than any other—out of fourteen specimens,

eleven ranged from fourteen to eighteen years of age. With regard to the lower end of the radius, which came next in order of frequency, I found the age to be somewhat under this—from twelve to sixteen years in seven specimens. This pathological fact, if I may so call it, is further borne out by the statistics of simple separations that have hitherto been published. M. Delens, in the *Archives Générales de Médecine*, has also noted this fact in a collection of twenty-seven cases of the lower end of the femur; the period he gives for this epiphysial separation is from ten to eighteen years of age. This does not appear to be so accurate as the period just given, since he has collected every case he could find published, whether simple or pathological; many of the former cannot be relied on, being evidently due to disease in the bones, and occurring in infants, thereby making the average period too low. This peculiarity of each bone can, I think, be explained on anatomical grounds. There is a certain time in each when the opposed ends of the epiphysis and diaphysis are converted into tolerably firm bone, with a thin wavy lamella or disc of cartilage intervening. Now, at this period the separation usually occurs directly through or close to the epiphysial line of junction, more or less in a transverse direction, so that we get a true simple separation. Before and after this time, the anatomical conditions of the ends of the bones are altered, ossification being either too far or not far enough advanced, *i. e.*, the epiphysis is in part united to the shaft or itself not perfectly ossified, but composed of yielding and elastic cartilage; hence we discover *not* a simple but often a very complicated fracture through the epiphysis or diaphysis.

I have come to the same conclusion after many experiments on the dead body.

Rickets, scurvy, syphilis, epiphysitis, tuberculous disease and other affections may so hasten or retard the process of union of the epiphysis with the shaft as to alter entirely the most frequent period at which the separation of that particular bone takes place in a healthy subject. This aspect of our subject under consideration, although exceedingly interesting, is too large a one for me to further enter into here.

2. *Mobility of an Epiphysis.*—After the question of age, this sign is the most important. If we find mobility in or near to the epiphysis in a young subject below twenty-one years



of age, the history of whose injury we have informed ourselves of, we have sufficient evidence without any other to suggest at once to our minds the occurrence of an epiphysial separation. If with these two signs we discover any of the others to be mentioned subsequently, the diagnosis of the lesion should be made with great accuracy.

Locking of the diaphysis into the hollow of the epiphysis may, in a few cases, effectually prevent any mobility being detected.

3. *Displacement at an Epiphysial Line of Junction.*—It is quite impossible to make an accurate diagnosis if we do not have a clear conception of the precise anatomical features of each epiphysis, the direction of each epiphysial line of cartilage, and its distance from the joint or interarticular line. Sir Astley Cooper, in his *Fractures and Dislocations*, does not directly allude to these injuries, and it is remarkable that so eminent a surgeon should have omitted a subject so important. This is what Sir Charles Bell says in his work on *Injuries to the Thigh-Bone* (1824), p. 41: "The advantage of taking anatomy as the ground-work of our observation is that nothing is forgotten. Had this method been followed by Sir Astley Cooper, writing professedly on the fracture and dislocation of the thigh-bone, he could not have neglected the subject of diastasis altogether—a fact so important both in the question of fracture and dislocation."

I may incidentally notice that the upper epiphysis of the humerus includes the tuberosities, the lower end of the femur, all the portion below the adductor tubercle, while the lower epiphysis of the humerus (after puberty) does not include the epicondyles, but only the external one with the trochlear and capitellar processes. It is unnecessary for me here to enter into the numerous and important features of each epiphysis. In a large proportion of instances the epiphysis is displaced more or less from the diaphysis, and in not a few it is complete. Examples are recorded in which the ends of the humerus, femur or radius were completely displaced and pressed upon important vessels and nerves.

Mr. Bryant mentions a case of displacement of the lower extremity of the humerus where the anterior border of the diaphysial end so injured the brachial artery as to occlude it, recovery, however, taking place. In other cases noted the

axillary or popliteal vessels were lacerated or pressed upon. The end of the diaphysis is usually smooth and flattened, and unlike the pointed end in a fracture. In complete displacements the periosteum is stripped off the shaft for many inches, and suppuration with necrosis of the shaft may ensue, more especially in compound separations; its connection with the epiphysis remains intact, being intimately connected with it. This stripping up of the periosteum will be found to occur to a greater or less extent, together with penetration of its sheath by the diaphysial, and this even when the displacement is not quite complete. These are points of the greatest practical significance. Without this knowledge I believe it impossible to make a correct diagnosis, at any rate in partial displacements, if only a few days have been allowed to elapse from the time of injury to that of making the examination. By this time the torn-off periosteum has inflamed and thrown out new osteoblastic material around, which fills up the angles and depressions between the displaced epiphysis and diaphysis, rendering their otherwise sharp outline obscure, besides diminishing the mobility in this situation, should this sign be then sought for. The inflammation of the periosteum, together with the œdematous condition of the soft parts in the neighborhood, will consequently defy an accurate investigation of the lesion, and no subsequent examination of the seat of lesion—that is after the surrounding œdema, etc., has subsided—will throw much light upon it, for the new bone will by that time have become more solid and unyielding.

It is well known how soon new osseous material is produced by the injured periosteum in children, a few days being quite long enough for a thick spongy layer to form. Even when the periosteum has not been torn off, spongy bone will be formed, simply as a result of the violence to it or in its neighborhood. I have seen it about the bones of the elbow-joint after a simple dislocation in a child. So shall we also find it when there has been no displacement of the epiphysis or diaphysis, but only a simple detachment of the epiphysis, without any displacement. However, as I have said, we usually find in this case some slight tearing up of the periosteum.

This brings me to another important practical point.

If separation of the epiphyses without displacement be

not well recognized, we shall probably overlook a considerable number of epiphysial injuries, as has been the case in by-gone days. I have already stated that, given the history of injury in a young patient below twenty-one years of age and, if on examination we find some mobility without deformity, *i. e.*, without displacement—corresponding to an epiphysis, an epiphysial separation should be thought of, or even diagnosed; otherwise, disastrous consequences may follow, particularly if the patient be allowed to move about with the lesion undetected, and for several reasons. The chief of these are: First, the ends of the bones may become gradually displaced and cause permanent deformity; or, secondly, cause pressure upon important structures.

Sir Charles Bell, in his "Injuries of the Thigh Bone," has recorded an instance in which there was a separation of the lower end of the femur. The accident occurred to a lad early in life. The boy, when getting on the back of a carriage, got his leg entangled in the spokes of the wheel, the force of which twisted off the epiphysis from the extremity of the diaphysis. About twenty years after, the patient, in jumping down from a chair, felt something snap and very soon after a pulsating tumor appeared, which was discovered to be a popliteal aneurism. The leg was finally amputated. This interesting specimen is now in the Museum of the Royal College of Surgeons of Edinburgh.

A somewhat similar specimen is in the Museum of the Royal College of Surgeons of England, from the practice of Robert Liston, and figured in his "Elements of Surgery." A girl sustained an injury to the knee when fourteen years of age, in consequence of the limb having been entangled in the spokes of a carriage wheel in motion; the knee continued painful and swollen, and she had a halt in walking. After the lapse of about three years extensive suppuration occurred in the lower part of the thigh and round the knee joint, and amputation very soon became imperative for the preservation of life. The synovial apparatus was found to be much diseased and the epiphysis of the lower end of the femur displaced forwards and upwards, so that only its posterior part rested on the tibia. In fact it was rotated almost half round on its shaft, and firm union by bone had taken place.



With our present knowledge of epiphysial injuries such results could hardly occur.

In the case last related, rotation of the epiphysis had evidently taken place after the accident, when the child had walked, but separation would assuredly have been diagnosed before the displacement had taken place, from the age of the patient together with mobility in the situation of the epiphysial line.

My investigations have satisfied me that most cases of arrest of growth of the long bones have been, in consequence of the injury not being diagnosed as an epiphysial separation, at the time of its occurrence.

Juxta-epiphysial sprains recently described by Ollier in their more severe forms are in reality partial separations of the epiphyses without displacement in infancy.

Fourthly, as to the *Modified Crepitus* met with in separations of the epiphyses.

If the separation be a simple one, that is to say a simple tearing of the conjugal cartilage from its shaft, with but few minute bony spicules remaining adherent to the epiphysis, then we shall find that the detached surfaces can be made to glide laterally or otherwise, over one another with a kind of "mortary" sensation. On the other hand, if large fragments of the diaphysis are broken off the diaphysis, as is frequently the case, the crepitus is of a more grating character, but still very different from the sharp, dry crepitus of an ordinary fracture.

When no displacement has taken place we must not expect to find crepitus, indeed, we should always make our diagnosis irrespective of it. We must not endeavor to obtain it in our examination, for, by so doing we do more harm than good by stripping up the peristeum still further. If, however, during our manipulation of the injured joint, we experience this sensation of crepitus, it is pathognomonic.

5. *Character of Displaced Diaphysis or Epiphysis.*—

When the end of the shaft may be seen projecting from the wound, and easily recognized by the flat surface, with its small elevations and depressions, I may at once dismiss the subject of compound separation, although in more than one compound case the diaphysial end has been mistaken for the articular extremity. In the injuries under consideration, whether the displacement be complete or not, we may usually

feel the angular margin of the diaphysis, very unlike the irregular, sharp projection of an ordinary fracture. If the displacement be complete, the finger of the surgeon may be placed in the more or less flattened "table like" end of the shaft. If many hours have elapsed since the time of the accident this sign will necessarily be greatly obscured. I am supposing now that separation has taken place through the whole extent of the conjugal line, and that it has occurred during the method mentioned above. This sign is common enough at the upper and lower ends of the humerus, but less so at the lower end of femur and radius. With regard to the last (separation of the lower epiphysis of the radius) I might add here that there is no such injury as Colles's fracture in children—*nearly* all are in reality separated epiphyses.

Now, unfortunately, a large proportion of the examples we see in practice do not present themselves as a complete separation; they are only *partial*, that is to say, the separation passes only through part of the epiphysial junction, and are often very complicated, being associated with fracture of the shaft or epiphysis or with dislocation of the neighboring joint. If to this be added the fact that separations may occur at any age from birth up to 20 or 23 years, and that the epiphysial fragment may be twisted or rotated on one of its axes, the enormous difficulties that frequently present themselves to us in practice are at once apparent. They will often tax the most skilled anatomist and surgeon to give a detailed description of the conditions presented. If an accurate anatomical knowledge be essential to the diagnosis of pure separations, how much more so must it be in these complicated and more common cases.

The following examples of partial separation of the epiphysis were under treatment by me in 1886. In the first a boy aged 6 years had been run over by a baker's cart, and the fracture had evidently traversed the inner half of the epiphysial line, and thence obliquely upwards through the lower third of the shaft. The inner part of the lower end of the diaphysis could be felt resting forwards. There was no fracture of the epiphysis, and the joint was intact. The elbow was put up in a "Crofts" splint, and the patient made a good recovery with an excellent limb.

The second is the case of a girl aged  $6\frac{1}{2}$  years. The sepa-

ration was through the outer part of the epiphysial line, then upwards and inwards through the diaphysis, the end of the outer part of the latter being felt in its displaced position forwards and outwards. The joint was normal. Not having seen the patient until more than two weeks after the accident, when I was called in consultation, a considerable amount of union had already resulted in this bad position. The movements of the elbow joint being unaffected, I recommended that the limb should be left in its condition, believing that it would be a very useful one, that the existing deformity would be moulded down by nature, but that irregular growth of the arm might (though very improbably) ensue.\*

A good example of partial separation, complicated with dislocation, is to be seen in a specimen in Guy's Hospital Mu-



Author's dissection (in 1853) of the specimen of separation of the carpal epiphysis of the radius in the Museum of Guy's Hospital (No. 1117<sup>42</sup>). The opposite half of the specimen is in the Museum of the Royal College of Surgeons of England (No. 956<sup>43</sup>). Drawn by Dr. C. W. Hogarth.

seum. It was taken from a boy aged 10 years, whose elbow joint was excised by Mr Bryant six weeks after the accident, on account of complete uselessness of the joint. On dissection I found separation and external rotation of the outer half of the epiphysis, associated with dislocation inwards of both bones of the forearm. Dr. T. H. Packard, of Philadelphia, in "Ashhurst's Encyclopedia of Surgery," mentions two

\* No arrest of growth occurred, and the functions of the elbow were scarcely at all interfered with, although some slight deformity remained many years afterward.—J. P., 1897.

cases of separation of the lower epiphysis of the humerus entirely within the joint, and no perceptible deformity, and Mr. Hutchinson has recorded a few partial separations with complications. Our present knowledge of these complicated cases is most scanty, and will remain so unless more accurate observations and records are the rule and not the exception.†

In some of the long bones these partial separations are the rule and pure separations the exception, *e. g.*, at the lower end of the humerus; in others the converse rule will apply. At the lower end of the radius the detachment is most often exactly through the epiphysial line.

Doubtless, as Mr. Holmes states in his "Surgical Diseases of Children," many of the specimens of separated epiphyses in the museums present a few lamella or granules of the diaphysis still adhering to the epiphysis; yet I am of opinion, with many others, that these fragments are not of sufficient size to warrant the surgeon placing the injuries under the head of partial separations, nor to distinguish them, clinically, from complete or pure separations.

6. *The Joint is Often Uninjured.*—The epiphysis usually retains all its normal relations to the other bones forming the joint. This is true as regards the pure, as well as the partial, separation; as instances of these I may refer to the lower ends of the radius and humerus, examples of which I have quoted above. The prognosis is far better than if these were complicated, as so rarely occurs, by a fracture into the joint, but most often seen at the lower end of the femur.

In conclusion let me put together some of these salient points in an early diagnosis. A child is brought to us who has met with an injury near a joint—it may be a severe one, the patient may have been run over by a cart, or, on the other hand, have merely twisted its limb. On examining the limb we find some mobility about its joint. A separated epiphysis at once occurs to our mind. Dislocation in children, being so rare, is to be at once discarded. If the child be of a certain age, say 15 years, and it is the lower end of the radius that is involved, it will be of the complete variety, and if there be

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† The recent skiagraphic process, 1896, will in the near future probably furnish some accurate data for the elucidation of all epiphysial lesions, but more especially at the elbow joint.—J P., 1897.



displacement we shall feel the flattened end of the shaft. If any time have elapsed from the time of the accident, and swelling obscures the neighborhood of the injury, the patient should at once be placed under an anesthetic, for in all these injuries an accurate diagnosis ought to be made at once.

If the case has been neglected, the soft structures around will have become swollen and the stripped up periosteum will have passed out porous bone, which I have already stated obscures the angular displaced ends. If many days supervene before a careful examination is made, the case will defy the most skilful surgeon.

Now, supposing we have a case where there is mobility (without any displacement to guide us), what will be the result if the nature of the injury be overlooked? The child is allowed to move about, and gradual displacement of the epiphysis or suppuration may result, with its consequences, as shown in many examples in our museums. Acute periostitis and necrosis are common results of the latter.

Sir Charles Bell records an example of this in a lad about thirteen years old, who had fallen through an open floor between the joists so as to twist the leg, and the effect was supposed to be a fracture near the knee joint. Suppuration took place in the joint, and by the delirious restlessness of the patient, and ulceration of the integuments, the bone was thrust through. It was then found that it was not a fracture, but that the spongy end of the diaphysis projected, whilst the epiphysis retained its connection with the joint. The specimen is in the museum of the Royal College of Surgeons of Edinburgh.

I believe that separation without displacement, often partial in character, is a frequent cause of acute disease of the hip joint.

Then again the epiphysis may become gradually displaced and produce permanent deformity or pressure upon important structures, so that an aneurism may develop. In later years arrest of growth may result.

Again, if the accident happened to a child either above or below the period of age in which pure separation usually occurs, all forms of partial separation and complications are likely to be met with, and present, as I have already said, the most frequent and difficult class of injuries. While attention



is being directed to the fracture or dislocation, the separation through part of the epiphysial line may be overlooked. Subsequent irregular growth of the end of the diaphysis may result from the partial separation and bring discredit on the surgeon. In this way genu valgum or varum may arise in the lower extremity. An anesthetic should therefore be administered and an exact diagnosis made at once.

One word as to treatment. It is a most consoling point that epiphysial separations readily unite, indeed much more readily than fractures. There is no specimen in the Pathological Museums in London, and I know of no instance of a permanently ununited epiphysial end of a large bone which has been separated by violence. Each case must be treated on its own merits, the displaced ends immediately and accurately reduced, and the ordinary rules of treatment of fractures followed. "Crofts" splints of plaster of paris are excellent forms, since they can be so easily reapplied.

Difficulty of reduction is not uncommonly due to the transfixing of the periostial sheath by the end of the diaphysis, which is tightly held in a "button-hole" manner, or tags of periosteum may be folded over between the fragments. Under these circumstances, especially at the lower end of the femur and upper end of the humerus, operative measures are absolutely necessary for perfect coaptation and retention of the natural functions of the limb.

Above everything in partial separations let us give a warning prognosis and inform the parents at once of the deformity that may in all probability ensue in after years. Great credit for our diagnosis may in this way be obtained.